

- Appendix H -- Appendix M (PDF - 6,371K)

1998

**ASSESSING EXPOSURE TO AIR TOXICANTS FROM ENVIRONMENTAL TOBACCO SMOKE. 94-344. University of California, Berkeley.**

**Objectives:** To estimate the proportion of Californians' exposures to 17 selected TACs that is attributable to ETS and the proportion that is attributable to other sources. In addition, the study estimated the potential future reduction in exposure to these ETS chemicals that is likely to result from changes in Californians' smoking habits, new smoking laws, and other factors.

{ **Findings:** ETS was found to contribute significantly to the exposure of nonsmokers to TACs. For example, in the mid-to-late 1980s, the estimated average contribution of ETS to benzene exposures was 3-10% of the total benzene exposure; benzene is a potent carcinogen. Because of legislation prohibiting smoking in enclosed workspaces and other factors, ETS-caused exposures to the VOCs is predicted to be reduced in the late 1990s by 60-80% for adults, 45-55% for adolescents, and 30-35% for children. The smaller reduction for adolescents and children is due to the fact that these groups spend a greater portion of their time in unregulated indoor environments such as private residences.

**Importance to ARB's Program:** Results from this project can be used in conjunction with other recently available data to estimate the relative contributions of indoor and outdoor sources of these TACs to Californians' current exposures and risks. This information will help the ARB identify effective mitigation strategies for reducing the residual public health risks from these TACs.

**DEVELOPMENT OF A MODEL FOR ASSESSING INDOOR EXPOSURE TO AIR POLLUTANTS. A933-157. Geomet Technologies, Incorporated.**

**Objectives:** To develop a user-friendly model to estimate the population's average and high-end exposures to both gaseous and particulate pollutants. The model will use indoor concentration data, California activity patterns data, indoor source emission data, air exchange rate data, and other information.

**Findings:** Researchers on this project succeeded in developing a unique California Population Indoor Exposure Model (CPIEM). CPIEM can incorporate detailed human activity information, pollutant concentration data, and other California-specific data to

provide improved indoor and total exposure estimates for the California population. The model is flexible; it provides population exposure and inhaled dose estimates for different exposure times, up to eight different types of indoor environments, the outdoor environment, and the total exposure across all environments. The exposure module allows the user to specify the population characteristics, such as age, gender, and county of residence. The model estimates the central tendency of exposure distributions well, but, like other population exposure models, is less reliable in estimating the extremes (high and low ends) of the distributions.

***Importance to ARB's Program:*** The improved estimates of exposure will improve the accuracy of risk estimates, which will help the ARB identify and design more effective methods of risk management. It will especially improve indoor assessments required for ARB Toxic Air Contaminants Program actions under the California Health and Safety Code, section 39660.5.

- [Ch 1 -- Ch 6 \(PDF 3,002K\)](#)
- [Ch 7 -- Appendix D \(PDF 3,132K\)](#)
- [CPIEM User's Guide \(PDF 7,292K\)](#)

1996

#### DETERMINATION OF FORMALDEHYDE AND TOLUENE DIISOCYANATE EMISSIONS FROM INDOOR RESIDENTIAL SOURCES. 93-315. Battelle.

***Objectives:*** To measure the emissions of formaldehyde and toluene diisocyanate from their indoor sources. Measurements were made in medium and large chambers under conditions that reflect typical indoor conditions as well as conditions approximating extreme but realistic indoor conditions that would cause higher emissions.

***Findings:*** Major residential sources of formaldehyde generally emit less formaldehyde than in the past, but some products, including pressed wood products, permanent press fabric, and a wood floor finish, still emit significant amounts of formaldehyde. Toluene diisocyanate was not emitted in measurable amounts from any of the residential sources tested.

***Importance to ARB's Program:*** Formaldehyde and toluene diisocyanate can cause adverse health effects at low levels and are used in the manufacture of products widely found and used inside residences and offices. The results will be used to better estimate Californians' exposures to these compounds and to provide guidance to California citizens on steps they can take to reduce their exposures to them.

- [Disclaimer -- References \(PDF - 5,310K\)](#)
- [Appendix A -- Appendix G \(PDF - 5,071K\)](#)

1994

**TOXIC VOLATILE ORGANIC COMPOUNDS IN ENVIRONMENTAL  
TOBACCO SMOKE: EMISSION FACTORS FOR MODELING EXPOSURE  
OF CALIFORNIA POPULATIONS. A133-186. Lawrence Berkeley  
Laboratory.**

**Objectives:** To measure the levels of over 20 toxic air pollutants in aged second-hand smoke (ETS) from the brands of cigarettes most smoked in California. In order to compare the results with existing data, emissions of the same pollutants from fresh sidestream smoke (smoke from the burning end of the cigarette, or SS) were also measured.

**Findings:** Most of the target compounds were present in levels high enough to be measured in both ETS and SS. ETS emissions were highest for particles, aldehydes, nicotine, and the aromatic hydrocarbons. The ETS emissions were fairly consistent among the different cigarette brands, even when "regular" cigarettes were compared to mentholated and "light" cigarettes. ETS emissions were generally higher than emissions measured in SS, apparently due to chemical losses in the SS apparatus. The ETS emission factors agree with other literature values and the investigators recommend their use in exposure modeling.

**Importance to ARB's Program:** Cigarettes are a major indoor source of many toxic air pollutants. This study provides unique information to help estimate Californians' exposures to many toxic components of ETS.

- [Entire Report \(PDF - 7,575K\)](#)

1993

**DATABASE DEVELOPMENT AND DATA ANALYSIS FOR CALIFORNIA  
INDOOR EXPOSURE STUDIES. A133-187. Research Triangle Institute.**

**Objectives:** To combine data from six California indoor exposure studies into a unified database to facilitate further analysis of the data from all the studies. Also, to demonstrate the usefulness of the consolidated database by conducting several analyses, such as examining differences in exposure across seasons and location.

**Findings:** Data from six California exposure studies are now

compatible and can be easily accessed through the database. The analytical results suggest that indoor and personal exposures are higher in winter than in summer for common volatile organic compounds. Some indoor exposures to chemicals correlate with the presence of indoor emission sources and human activities in the home.

**Importance to ARB's Program:** The ARB will use the database to more fully analyze the large body of exposure information collected by the ARB and the U.S. EPA in California over the last decade. The database has already been used to estimate Californians' exposures to about 20 toxic pollutants for the California Comparative Risk Project.

#### **INDOOR CONCENTRATIONS OF POLYCYCLIC AROMATIC HYDROCARBONS IN CALIFORNIA RESIDENCES. A033-132. Research Triangle Institute.**

**Objectives:** To measure the levels of selected toxic combustion by-products (PAHs and carbon monoxide) in California homes and evaluate the relative contributions of sources -- such as cigarette smoking, wood-burning stoves, and gas heaters -- to indoor levels of those pollutants.

**Findings:** Cigarette smoking, wood stoves, fireplaces, and kerosene heaters were major sources of PAHs in the homes where they were used. Infiltration of polluted outdoor air also contributed significantly to indoor levels. Only a few homes showed elevated levels of carbon monoxide, associated mostly with the use of gas heat and fireplaces.

**Importance to ARB's Program:** The findings will be used to estimate Californians' indoor exposures to PAHs and carbon monoxide and to provide guidance to the public on how they can avoid unhealthful exposures.

#### **MEASUREMENT OF BREATHING RATE AND VOLUME IN ROUTINELY PERFORMED DAILY ACTIVITIES. A033-205. University of California, Davis.**

**Objectives:** To measure the amount of air breathed during routine activities in the first comprehensive study of males and females of all ages, in order to fill a major data gap in exposure/dose calculations.

**Findings:** The amount of air breathed during defined activities and for various age groups is now known. Adult males of all ages breathe similar amounts of air during similar activities. Likewise,

adult females of all ages breathe similar amounts of air during similar activities. This study confirmed that, relative to body size, children breathe more air than adults during similar activities. Contrary to other studies, the investigator found that heart rate is not a good predictor of pulmonary ventilation at all exercise levels.

***Importance to ARB's Program:*** The ARB and other groups are using these breathing measurements to refine estimates of the amount of air pollutants inhaled. This study eliminates much of the uncertainty of estimating inhaled dose from laboratory measurements by actually measuring the amount of air breathed by a wide variety of individuals during actual activities.

- [Entire Report \(PDF - 6,517K\)](#)

1992

**PTEAM: PARTICLE TOTAL EXPOSURE ASSESSMENT METHODOLOGY STUDY. A933-144. Research Triangle Institute.**

***Objectives:*** To measure exposures to inhalable particles and some associated elements. ARB participation ensured that the study was conducted in California and provided funding for measuring indoor and outdoor levels of two classes of toxic air pollutants: PAHs, which are combustion by-products, and phthalates, which are commonly used plasticizers.

***Findings:*** Personal monitoring showed that people are exposed to about 50% more PM during the day than would have been predicted using stationary monitors. Indoor PAH levels ranged from about one-half to two times outdoor levels. Phthalates were ubiquitous, and average indoor levels were 2 to 15 times higher than outdoor levels.

***Importance to ARB's Program:*** The ARB is using the data to assess Californians' indoor and personal exposures to inhalable particles and a number of toxic air pollutants, including benzo(a)pyrene, phthalates, lead, and other metals.

- [Section 1 -- Section 7 \(PDF - 3,514K\)](#)
- [Section 8 -- Appendix C \(PDF - 2,476K\)](#)
- [Appendix D -- Appendix K \(PDF - 1,157K\)](#)

1991

**ASSESSMENT OF INDOOR CONCENTRATIONS, INDOOR SOURCES, AND EMISSIONS OF SELECTED ORGANIC COMPOUNDS. A933-063.**

**Lawrence Berkeley Laboratory.**

**Objectives:** To survey and summarize available information on indoor concentrations and sources of 47 toxic air pollutants and identify data gaps that could be filled by conducting indoor source emissions tests.

**Findings:** Except for four of the compounds, available data are generally not sufficient for estimating indoor exposures. The investigators identified compounds for which it would be useful to conduct indoor source emission tests and outlined a general plan for conducting such tests.

**Importance to ARB's Program:** The information compiled on indoor concentrations and sources has been used to estimate indoor exposures for the Toxic Air Contaminants Program. This project prompted two further ARB studies to measure emissions from indoor pollutant sources.

- Pg. 1 -- Pg. 84 (PDF - 5,562K)
- Pg. 85 -- Pg. 179 (PDF - 5,829K)

**INDOOR POLLUTANT CONCENTRATIONS AND EXPOSURES. A833-156.**  
Research Triangle Institute.

**Objectives:** To measure indoor air levels of pollutants to be addressed in the Toxic Air Contaminants Program; to determine whether indoor/personal air levels in a small, inland Northern California community are similar to those in Los Angeles; and to attempt to measure for the first time the indoor concentrations of certain semi-volatile pollutants.

**Findings:** This study confirmed findings of previous California studies that personal exposure levels to VOCs are somewhat higher than indoor air levels and that indoor levels of many VOCs are higher than outdoor levels. The indoor and personal VOC levels were similar to those measured in other northern California homes, but lower than those found in southern California homes. Semi-volatile chemicals were difficult to measure, but appeared to be low indoors.

**Importance to ARB's Program:** The data have been used to estimate indoor exposures to several pollutants for the Toxic Air Contaminants Program, as required under the California Health and Safety Code. The results are also being used to estimate Californians' indoor and total exposure to air pollution for the Comparative Risk Project and to provide guidance to help the public reduce their exposures to these pollutants.

**ACTIVITY PATTERNS OF CALIFORNIA RESIDENTS. A6-177-33.**  
**University of California, Berkeley.**

**Objectives:** To obtain representative data on the time spent by California adults and adolescents in different activities and locations, with the focus on potential exposure to harmful air pollutants. Also, to examine regional, seasonal, and socioeconomic/demographic differences.

**Findings:** Adults and adolescents spend, on average, 62% of their time indoors at home, 25% indoors at other locations, about 6% outdoors, and 7% in enclosed transit. The frequency, duration, and time of day of potential exposures to various indoor and outdoor air pollutants varied greatly across the population.

**Importance to ARB's Program:** The findings improved the ARB's understanding of how and where Californians are exposed to air pollution. The results are being used to improve the indoor exposure assessments for TACs required by the California Health and Safety Code. The ARB, other agencies, and researchers are using the data in models to more accurately estimate people's exposures to pollutants.

- [Entire Report \(PDF - 5,783K\)](#)

**STUDY OF CHILDREN'S ACTIVITY PATTERNS. A733-149. University of California, Berkeley.**

**Objectives:** To obtain representative data on the time spent by California children in different activities and locations, with the focus on potential exposure to harmful air pollutants. To examine regional, seasonal, and socioeconomic/demographic differences to the extent possible.

**Findings:** Children spend, on average, 76% of their time indoors at home, 10% indoors at other locations, about 10% outdoors, and 4% in enclosed transit. Potential exposure to pollutants as a result of activity patterns was quite variable.

**Importance to ARB's Program:** The findings improved our understanding of how and where children are exposed to air pollution and how to most effectively reduce the resultant health risks. The ARB, other agencies, and researchers are using the data in models to more accurately estimate people's exposures to

pollutants.

- [Acknowledgments -- References \(PDF - 3,914K\)](#)
- [Appendix A -- Appendix D \(PDF - 2,279K\)](#)

1990

**DEVELOPMENT OF A METHOD FOR MEASURING INDOOR CONCENTRATIONS OF POLYCYCLIC AROMATIC HYDROCARBONS. A732-106. Indoor Environmental Engineering; Lawrence Berkeley Laboratory.**

**Objectives:** To develop sampling and analytical methods in the laboratory for monitoring indoor concentrations of PAHs, which are toxic by-products of combustion, and field test these methods to determine their feasibility for use in larger studies.

**Findings:** The investigators successfully developed methods to measure gas phase PAHs indoors. They concluded that methods for measuring particle-phase PAHs and gas phase nitro-PAHs required further development prior to field use.

**Importance to ARB's Program:** Results from this project were used during the development of the monitors for two large-scale ARB residential PAH studies (A933-144, 1992 and A033-132, 1993).

**PTEAM PILOT: EVALUATION OF METHODS FOR MONITORING PAHs, PHTHALATES, NITROSAMINES, AND ACIDS. A833-060. Research Triangle Institute.**

**Objectives:** To field test indoor sampling and analysis methods for four classes of air pollutants (PAHs; phthalates; nitrosamines; and acids) in nine southern California homes to ensure that resources would be properly focused in a proposed, larger field study.

**Findings:** The investigators demonstrated the feasibility of measuring PAHs and phthalates indoors and refined the methods for use in the larger study. They determined that the methods for monitoring indoor levels of nitrosamines and acids required further improvement and testing prior to use in the field.

**Importance to ARB's Program:** The methods for PAHs and phthalates were used in the subsequent large field study (A933-144, 1992). Nitrosamines and acids were dropped from the

sampling plan. The PAH and phthalate methods were also used in another residential study sponsored by ARB (A033-132, 1993).

**STUDY OF RESIDENTIAL INDOOR AND OUTDOOR RADON CONCENTRATIONS IN CALIFORNIA. A6-194-53. California Public Health Foundation; California Department of Health Services.**

**Objectives:** To characterize the magnitude of the radon problem in California through the first statewide study of radon levels in air, soil, and water in randomly selected residences.

**Findings:** The statewide annual average indoor radon concentration was about 60% of the national average and well below the U.S. Environmental Protection Agency's (EPA's) recommended action level. The radon concentrations in the Sierra foothills and Ventura County were elevated relative to those in the rest of California.

**Importance to ARB's Program:** Results from this study have been used by the ARB and the Department of Health Services (DHS) to estimate Californians' exposures to radon, and by DHS and the U.S. EPA to guide additional monitoring efforts for further characterizing possible problem areas in the state.

- Entire Report (PDF - 3,682K)

1989

**DEVELOPMENT AND IMPLEMENTATION OF EXPOSURE ASSESSMENT PROCEDURES FOR TOXIC AIR POLLUTANTS IN SEVERAL LOS ANGELES COUNTY (CALIFORNIA) COMMUNITIES (also called the 1987 TEAM study). A5-174-33. Research Triangle Institute.**

**Objectives:** To determine similarities and differences in air levels of VOCs in 50 Los Angeles homes monitored three years earlier. Also, to identify possible indoor sources of the pollutants and estimate the rate of pollutant emissions from those sources.

**Findings:** The personal and indoor air levels were higher than outdoor levels for most of the pollutants. These findings were similar to those of the previous study. Indoor source strengths were successfully calculated for 12 prevalent compounds. A few were notably high.

**Importance to ARB's Program:** The results have been used extensively to develop estimates of Californians' exposures to toxic VOCs from inhalation of indoor air, as required by the California Health and Safety Code. The results also have been used in the

Comparative Risk Project and to provide guidance to the public on ways to reduce their exposures to these pollutants.

**PILOT STUDY TO MEASURE INDOOR AND PERSONAL PM10, ASSOCIATED IONS, AND MUTAGENIC ACTIVITY. A6-129-33. University of California, Irvine.**

**Objectives:** To test sampling equipment and methods for measuring indoor and personal exposures to respirable particles (PM10) and particle constituents and properties relevant to assessing health effects.

**Findings:** Different types of sampling equipment were tested in the laboratory and inside and outside ten southern California homes of asthmatics. This study successfully demonstrated the feasibility of monitoring indoor and personal exposures to particles and their constituents in a large field study.

**Importance to ARB's Program:** This study helped set the stage for conducting a large-scale residential particle study (called PTEAM) co-funded by ARB and U.S. EPA (A933-144, 1992).

- [Entire Report \(6,632K\)](#)

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